Use of Station Dependent Correlated Noise in Solve

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Summary

This document describes how to use station dependent correlated noise in solve. Empirical tests using the CONT05 sessions showed that including 6ps of correlated atmosphere noise reduced baseline scatter by ~12% and improved agreement between VLBI and IGS estimates of EOP.

Turning on Correlated Noise in Solve

Correlated noise is controlled by a line in the $SETUP section of solve. It can be turned on in solve using the following syntax:

```
APRIORI_OBS_CORR  REQUIRED noise_wt.txt
```

Here noise_wt.txt is a file that contains information about the noise. This file is required. Correlated noise can be turned off by either not including or commenting out the above line, or by using the syntax

```
APRIORI_OBS_CORR  NONE
```

Note: Correlated noise is incompatible with saving ARCFILES and FAST_MODE. If either of these are specified in addition to correlated noise, solve with exit with an error.

Noise Weight File

The noise weight file consists of a series of lines which indicate how much noise and of what kind to add to the observational noise. The noise for each station can be different.

The list below indicates the kind of noise that the software recognizes, and gives the functional dependence.

Kind	**Name**	**Functional dependence**
Clock	CLOCK	1
Azimuthal	AZIMUTH	Tan(el)^(-2/3)
Mapping function	MAP	map
Mapping function error	DMAP	map^3

In addition, there are two TYPES of noise:

Type	**Explanation**
DIAGONAL	Adds specified to all observations involving given station.
FULL	Adds specified noise^2 to all observations involving given station. In addition, modifies observation covariance matrix for other observations in this scan involving this station.

The lines in the weight file take the form:

`[dbname | global ] [Full|Diag] [CLOCK|AZIMUTH|MAP|DMAP]  values`

Lines in the weight file that start with a ";" are comments.

When solve is processing a particular database, it passes the name and the number of stations in the database to the subroutine that reads the noise-weight file. The subroutine reads the lines in the file until it encounters a line whose first token is:

1. The name of the database.
2. The literal `global.` This token indicates that all databases have the same noise values.

The subroutine parses this line. The second token determines the type of noise, the third token the kind, and the last value(s) the magnitude of the noise.

1. If the first token is `global,` the subroutine will read the first value from the value array, and assign this amount to all stations in the current database.
2. If the first token is a database name, the subroutine will read one value for each station in the database.

The subroutine will continue parsing lines until the first token changes.

Example1:
This file assigns 8 picoseconds of diagonal noise to all stations in all databases.

```
;Diagonal atmospheric weights.
global  diag  map 8
<EOF>
```

Example2:
This file includes both mapping function and clock noise. The noise varies from session to session, and from station to station.

```
;Station dependent clock and atmosphere weights.
$05SEP12XA FULL MAP      7.55  12.97   9.24  13.06  10.98  11.27  17.16   6.54  18.36  14.67  11.21
$05SEP12XA FULL CLOCK    6.34   9.84   7.38   8.86   8.45   8.34  12.76   5.68  11.32  10.20   8.25
$05SEP13XA FULL MAP      9.21  11.41   8.56  18.42   9.19  12.69  12.32   5.07  22.84  10.14   8.76
$05SEP13XA FULL CLOCK    7.32   9.22   6.85  11.28   7.63   9.42   9.80   5.01  13.33   7.12   7.05
$05SEP14XA FULL MAP      7.38   8.79   6.74  17.50   8.00   9.54  11.33   6.30  12.10  10.45   9.00
$05SEP14XA FULL CLOCK    6.42   7.36   5.94  10.56   6.74   7.41   9.04   5.57   8.54   7.52   7.07
$05SEP15XA FULL MAP      6.58   9.59   7.56  15.67   8.94   7.59   8.47   5.69  11.04   9.54  10.57
$05SEP15XA FULL CLOCK    5.93   7.90   6.43   9.78   7.29   6.25   7.17   5.20   7.64   7.12   7.85
$05SEP16XA FULL MAP      6.85   9.52   8.09  11.39   9.29   8.49  12.82   6.06  12.86  16.69   8.27
$05SEP16XA FULL CLOCK    6.00   7.82   6.69   8.17   7.64   7.11  10.39   5.46   8.99  10.05   6.84
$05SEP17XA FULL MAP      8.47  12.28   8.78  15.31   9.74  10.83  16.41   6.32  13.55  13.23  12.71
$05SEP17XA FULL CLOCK    6.90   9.79   7.21   9.79   7.98   7.94  12.80   5.59   9.68   8.54   8.79
$05SEP18XA FULL MAP      7.89  13.08  10.29  20.25  10.77  11.94  19.07   7.36  22.47  11.37  13.83
$05SEP18XA FULL CLOCK    6.53  10.03   7.98  11.98   8.68   8.53  14.19   6.15  14.06   7.96   9.95
$05SEP19XA FULL MAP     12.95  13.73  10.46  14.84  10.69  12.33  14.22   6.80  24.04  15.88  14.42
$05SEP19XA FULL CLOCK    8.81  10.34   7.97   9.46   8.58   8.85  10.92   5.83  13.68  10.27   9.95
$05SEP20XA FULL MAP      7.87  12.04   6.78  18.61   9.00  10.48  14.86   5.73  18.27  14.25  10.86
$05SEP20XA FULL CLOCK    6.63   9.34   5.96  11.09   7.41   7.95  10.93   5.32  10.84   9.25   8.00
$05SEP21XA FULL MAP      8.00  10.36   7.89  18.33   8.24   9.61  14.28   6.45  12.80   9.16   7.95
$05SEP21XA FULL CLOCK    6.71   8.26   6.52  10.72   7.02   7.45  11.15   5.69   8.87   6.97   6.68
```

```
$05SEP22XA FULL MAP      8.48  16.03  11.83  16.94  10.45  10.07  20.14   6.82  21.09  17.38  10.91
$05SEP22XA FULL CLOCK    6.91  11.06   8.59  10.37   8.44   7.62  14.80   5.68  12.46  10.99   8.20
$05SEP23XA FULL MAP      8.13  12.04   8.39  15.03   7.47   9.67  12.45   5.71  16.95   9.62   8.82
$05SEP23XA FULL CLOCK    7.10   9.19   6.92   9.84   6.58   7.37  10.15   5.25  10.59   7.42   6.91
$05SEP24XA FULL MAP      8.32  11.34   8.95  16.03   8.98   9.38  13.73   6.23  22.63   9.67  11.34
$05SEP24XA FULL CLOCK    6.88   9.05   7.26  10.02   7.36   7.28  10.86   5.58  13.24   7.36   8.43
$05SEP25XA FULL MAP      7.98  11.32  10.07  14.67   8.31  12.45  16.40   6.18  16.29  14.13  10.85
$05SEP25XA FULL CLOCK    6.71   8.96   7.82   9.90   7.02   8.94  12.95   5.52  10.35   9.10   7.97
$05SEP26XA FULL MAP      9.04   9.16  11.65   8.61   9.99  17.16   6.15  13.38  12.87  11.88
$05SEP26XA FULL CLOCK    7.47   6.98   7.95   7.35   7.69  13.00   5.49   9.52   8.69   8.68
<EOF>
```

Suggestions on Using Correlated Noise

My suggestion is to use the simple weight file with full covariance:

```
;Diagonal atmospheric weights.
global  full  map 8
<EOF>
```

Although it seems intuitively obvious that the noise terms should depend on the stations, in the tests I have done I have seen little if any improvement.

If you use “diag” instead of “full” in the above, you get elevation dependent weighting. This also improves the results, but not by as much as including the effects of correlation.

The above example assumes 8 picoseconds of correlated noise. Values between 5-10 and seem to work about equally well.

Turn off baseline weights. It has been the practice at Goddard to use baseline dependent weights. It turns out that correlated noise gives the best results if all of the baseline weights are set to 0.

Effect of Diagonal and Full Noise on the Covariance Matrix

This section shows the effect of diagonal and full types of noise on the scan covariance matrix.

Diagonal. Suppose that we have a scan involving 4 stations, and that noise is uncorrelated. This is indicated by the token DIAGONAL in the noise weight full. Then the covariance matrix of these observations is given by:

	12	13	14	23	24	34
12	+ ( ) + ( )	0	0	0	0	0
13	0	+ ( ) + ( )	0	0	0	0
14	0	0	+ ( ) + ( )	0	0	0
23	0	0	0	+ ( ) + ( )	0	0
24	0	0	0	0	+ ( ) + ( )	0
34	0	0	0	0	0	+ ( ) + ( )

Here the top row and left column label the baselines. Focusing on baseline 12, the observational noise is . In the presence of additional atmosphere noise this is increased to: + ( ) +( ) , and similarly for the other baselines. The covariance matrix remains diagonal.

Full. In contrast, suppose that the noise is correlated. (This is indicated by the token FULL in the noise weight full.) Than the covariance matrix for this scan becomes:

	12	13	14	23	24	34
12	+ ( ) + ( )	( )	( )	−( )	−( )	0
13	( )	+ ( ) + ( )	( )	( )	0	−( )
14	( )	( )	+ ( ) + ( )	0	( )	( )
23	−( )	( )	0	+ ( ) + ( )	( )	−( )
24	−( )	0	( )	−( )	+ ( ) + ( )	( )
34	0	−( )	( )	−( )	( )	+ ( ) + ( )

Here the top row and left column label the baselines. Focusing on baseline 12, the observational noise is . In the presence of additional atmosphere noise this is increased to: + ( ) +( ) , and similarly for the other baselines. The covariance matrix remains diagonal. In contrast, suppose that the noise is correlated. Than the covariance